A Registry for Energy Savings

From Energy Efficiency Programs & Practices

MEASURES Project Deliverable 2.2.2: A "white paper" with recommendations for establishing a "registry" or similar system to track and validate energy efficiency credits from ESPC projects or other non-ratepayer funded programs.

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Clean Energy Solutions, Inc.

APPENDICES

A. AVERT Test Runs

B. Annual Displacement by County (AVERT output)

I. OVERVIEW & OBJECTIVES

This paper presents recommendations for a "Registry" of energy savings, particularly from energy-efficiency improvements to existing buildings, implemented through energy-saving performance contracts (ESPCs).[1] The paper's intent is to support future development of means to track, validate, and potentially trade units of energy savings and related units of avoided pollution emissions. Such development could serve to support more cost-effective crediting of energy savings to meet voluntary and regulated energy savings goals and targets and, potentially, as a more cost-effective means to meet state and federal emissions standards. [2], [3]

A registry should be designed to satisfy two audiences: those preparing or evaluating state energy plans and air quality plans (where, in the latter, energy efficiency can offer emissions avoidance as a side benefit); and those considering trading certificates representing validated energy savings (and associated emissions reductions) that may be denominated as credits, allowances, or "offsets," depending on applicable programs.[4] Both audiences are concerned with the rigor of: (a) the measurement and verification (M&V) of efficiency-based energy reductions, (b) the reductions of emissions (such as carbon dioxide (CO_2) or nitrogen oxides (NOx)) associated with the energy savings [5],[6] and (c) the tagging and "retirement" of each MWh[6] of reduced consumption and/or its associated mass of avoided emissions.

The importance of a mechanism to retire such certificates is to avoid double counting. Double-counting may occur when a certificate has not been properly identified as used or sold in one market, and

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[1] The MEASURES project seeks to develop Evaluation, Measurement, and Verification protocols and an energy efficiency tracking approach that integrate non-ratepayer funded ESPC programs into energy efficiency goals and standards programs and, potentially, for compliance with state and federal emissions standards.. This white paper discusses opportunities for establishing a "registry" or similar system to track and validate energy efficiency credits from ESPC projects or other non-ratepayer funded programs.

[2] This project began as the Environmental Protection Agency's (EPA's) Clean Power Plan (CPP) was being developed and promulgated. At the time of this writing the rule is under a U.S. Supreme Court stay pending litigation. The finalized CPP did not require conversion of energy savings to avoided CO_2 but such a conversion may be valuable for other purposes. Also, translating saved energy into other avoided emissions can be useful for meeting ambient air quality standards and other state and federal emission objectives.

[3] The CPP would allow states to opt for rate-based goals in which 1 MWh of electricity savings can earn 1 emissions rate credit (ERC) for compliance purposes or choose mass-based compliance where regulated electrical generating units (EGUs) would need to possess emission allowances, each representing 1 short ton of CO_2 to cover their emissions. Depending on state approaches, energy efficiency can play roles in both rate- or mass-based CPP compliance. Due to project timing, this paper centers on the CPP but broader applications of an energy efficiency registry are also noted.

[4] In cap-and-trade regulatory systems, those certificates can be bought by greenhouse-gas emitters to help meet their CO_2 mass limitation requirements in what are termed compliance markets. Certificates can also be traded in voluntary markets to meet voluntary goals and standards, such as corporate carbon-footprint goals or companies' and individuals' purchase of carbon "offsets."

[5] Pollutants other than CO_2 and, in principle, other environmental impact avoidance could also be tracked in a registry.

[6] With a focus on the CPP, this paper also focuses on electricity use and savings but a registry could also be used for non-electricity energy savings too, such as from avoided natural gas, fuel oil, propane, or coal consumption at facilities and saved transportation fuels.

therefore becomes available as an un-used certificate in either the same market or a different market. Emission reductions associated with one certificate may be counted twice, which leads to distorted data, inaccurate reporting, and distorted values in the market.

A National Energy Efficiency Registry (NEER) and similar bodies could provide such a registry service. [7], [8] These registries would provide confidence that certificates are properly issued, exchanged, and retired with clear ownership to well-demonstrated energy savings and concomitant emissions avoidance, and are not doubly or otherwise multiply counted. This could strengthen air quality regulator acceptance of energy efficiency measures as air quality management approaches since quantifying energy savings is more difficult than quantifying generation. Further, a registry could enhance State Energy Office and Public Utility Commission consideration of energy efficiency, particularly of non-ratepayer programs and measures, as energy resources and assets to include for reliability planning. And, importantly, by increasing buyer and regulator confidence in energy efficiency, a registry could stimulate greater supply of energy efficiency implementation. See Section V "Registry Design" for more detailed information on NEER.

Because each certificate is uniquely validated, identified, and retired, voluntary and compliance markets for certificates can exist side by side. Thus states can include the sale and trading of certificates as part of their compliance plans, while still sponsoring voluntary markets.

Scope of this paper. Due to the timing of this project, focus has been on applicability under the CPP but, as noted, a registry could serve broader energy efficiency and associated emission reduction markets, both regulatory and voluntary. The CPP would require a state to submit either an emission standard plan or a state measures plan. If the emission standards approach is selected, the state would impose emission standards directly on covered electrical generating units (EGUs) in the state, meaning that EGU owners would be responsible for either achieving needed emission or emission rate reductions on-site or, if the state elects to allow trading, trading for sufficient ERCs or allowances to meet the emission goal associated with each standard. Under a state measures plan, the state itself could take some of the emission reductions obligations although the CPP would still require a backup emission standards plan that would be triggered if the state failed to meet certain emission benchmarks. Emission standards plans can be either rate- or mass-based, but state measures plans can only be mass-based. Both emission standard and state measures plans can (as appropriate) allow interstate trading of ERCs or allowances.

Because the MEASURES[9] project was developed to anticipate CPP implementation, the project and the partner states have concentrated on electrical savings and emission reductions from electrical

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[7] In 2015, Tennessee, five other states (Georgia, Michigan, Minnesota, Oregon, Pennsylvania) and partners The Climate Registry (TCR) and the National Association of State Energy Officials (NASEO) won a competitive funding award from the U.S. Department of Energy (DOE) to develop a roadmap for a National Energy Efficiency Registry (NEER).

[8] Several registries covering renewable energy already exist in the United States. These support the issuance and trading of renewable energy certificates (RECs) which are used in some states for satisfying renewable portfolio standards or similar requirements as well as for voluntary REC markets.

[9] Virginia Department of Mines, Minerals and Energy (DMME) is the project lead, partnered with Kentucky and Georgia in this U.S. Department of Energy State Energy Program Project, DE-EE0006891, *Developing Consistency in EM&V Approaches and Emission Reduction Calculations for Energy Savings Performance Contracting Programs*. Other partner organizations include Clean Energy Solutions, Inc. (CESI), the National Association of State Energy

generating units (EGUs). However, ESPCs also provide thermal savings and direct emission reductions from reduced consumption of fossil-based fuels. Therefore, although a comprehensive Registry would track both electrical and thermal savings, the remainder of this paper focuses on electrical energy savings and the resulting emission reductions.

Over the course of the MEASURES project the CPP progressed from a proposal to a final rule. With ongoing litigation over the final rule and additional rule components under development (e.g., the federal plan and model trading rules and the Clean Energy Incentive Program), critical details of the CPP remain in flux. Though suggested in the proposed CPP, the conversion of electrical savings into avoided CO_2 emissions is not required in the final rule. That conversion, however, may be important for other purposes, for example, to understand efficacy of programs and policies and to support complementary policy objectives (e.g., Did an electric utility meet its energy efficiency resource standard (EERS) requirement or earn an incentive? Did an energy services company (ESCO) meet its ESPC guarantee and is the state's ESPC program delivering savings? etc.) Also, under the CPP mass-based states could opt for allowance allocation approaches (such as an "updating output-based allocation") where allowances are allotted to energy efficiency providers in proportion to savings achieved. So a registry could be useful under both rate- and mass-based approaches to CPP compliance.

The avoided emissions quantification may also have significant value along several other lines, even though it is not required for CPP compliance:

- Broad projection and tracking of CO_2 and other GHG emissions for planning purposes and programmatic assessments. Air quality regulators may want to know which policies and programs are contributing to GHG-related emissions goals and be able to adjust regulatory approaches based on the performance of energy efficiency measures and other compliance strategies. This would also be useful for state-level GHG goals and policies even in the absence of a CPP.
- Supporting an output-based allowance allocation for states that opt to include (and encourage) energy efficiency as an eligible resource for receipt of allowances under the CPP or, conceivably, under state or regional programs.
- Voluntary initiatives and markets such as for companies buying "green" power to help meet corporate carbon footprint goals.
- Addressing criteria air pollutants and other Clean Air Act program impacts and requirements.[10]

Officials (NASEO), the Southeast Energy Efficiency Alliance (SEEA), the National Association of Energy Service Companies (NAESCO), and the National Association of Clean Air Agencies (NACAA).

[10] Energy efficiency and renewable energy have been included in criteria air pollutant programs, such as eligibility for NOx "set-aside" allowances in several states and inclusion in National Ambient Air Quality Standards (NAAQS) State Implementation Plans (SIPs). (See U.S. EPA, 2012, "Roadmap for Incorporating Energy Efficiency/Renewable Energy Policies and Programs into State and Tribal Implementation Plans",(https://www.epa.gov/energy-efficiency-and-renewable-energy-sips-and-tips .) Energy efficiency is also cited by EPA in its Regional Haze guidance (U.S. EPA, 2016, "Draft Guidance on Progress Tracking Metrics, Long-term Strategies, Reasonable Progress Goals and Other Requirements for Regional Haze State Implementation Plans for Second Implementation Period," https://www.epa.gov/sites/production/files/2016-07/documents/draft_regional_haze_guidance_July_2016.pdf.)

II. MEASUREMENT, VERIFICATION, & CONVERSION

To properly quantify emissions reductions and credits to the satisfaction of prospective audiences, the actual MWh reductions caused by ESPC must be measured and verified by widely accepted protocols, such as the International Performance Measurement and Verification Protocol (IPMVP)[11], the Uniform Methods Project (UMP),[12] and the Federal Energy Management Program (FEMP) M&V Guidelines for Performance-Based Contracts V.4.0.[13] Although the IPMVP is almost universally used by ESCOs, it is designed with some flexibility, which makes its imposition and practice vary among states. Reviewing these M&V approaches and developing commonality in these practices is a key objective of the MEASURES project. [14]

Registry of ERCs and CO_2 Allowances

Once electrical energy savings (in MWh) have been computed from ESPC energy savings, those units must be registered to make them tradable for value. The purposes of this accounting are to establish:

- Association and Certification – Each MWh of eligible savings (avoided consumption) yields one "emission rate credit" (ERC) under the CPP
- Attribution -- What is the source of each ERC—which State, program, ESCO, customer, year, and contract produced it? And who owns it?
- Identification -- Assigning a unique identifier to each ERC, with its attribution, and entering it into a secure inventory
- Issuance
- Transaction recording -- If a unit's ownership is transferred for value (monetary or other), recording that value and the new ownership
- Retirement -- removing that unit from the inventory permanently

The NEER project contemplates a structure that includes the following components: [15]

- Accounts: energy efficiency providers and buyers of energy efficiency credits create NEER accounts.

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[11] The IPMVP was developed and is published by the Efficiency Valuation Organization and is available via http://evo-world.org/en/.

[12] U.S. DOE, Uniform Methods Project for Determining Energy Efficiency Program Savings http://energy.gov/eere/about-us/ump-home.

[13] U.S. DOE, FEMP, 2015, "M&V Guidelines: Measurement and Verification for Performance Based Contracts, Version 4.0," http://energy.gov/sites/prod/files/2016/01/f28/mv_guide_4_0.pdf.

[14] The project produced several relevant white papers, including "Evaluation, Measurement and Verification Protocols" and "Recommended ESPC M&V Principles Development." These and other project papers are available at: http://seealliance.org/initiatives/state-local-utility-policy/emv-approaches-performance-contracting/.

[15] Drawn from the Center for Energy and Environment webinar "Shaping the Tradability of U.S. Energy Efficiency: Outreach to Minnesota Stakeholders on the National Energy Efficiency Registry (NEER)" (August 11, 2016), especially slides 35-48 https://www.mncee.org/resources/resource-center/webinars/shaping-the-tradability-of-u-s-energy-efficiency/.

- Assets: energy efficiency providers register projects by identifying them, showing their eligibility under the CPP or other program for which credit would be sought, and attest to exclusive ownership of the energy savings (or other "output") for which credit will be sought.
- Asset Output: energy efficiency providers report on MWh (or possibly Btu or other units of energy efficiency "output") for which they wish to make a claim and register; they provide requisite M&V reports and associated quality assurance/quality control.
- Commoditized Instruments: NEER deposits energy efficiency certificates based on verified output into the energy efficiency provider's asset account.
- Transactions: following a bilateral contract between certificate owner and a buyer, the NEER transfers the certificates to the buyer's account.
- Retirement: buyer retirement of certificate is followed by NEER confirmation and documentation of the retirement.

The above refers to energy efficiency certificates but the instrument issued could be termed a certificate, credit, allowance, or something else depending on purpose; for example, ERCs under the CPP (if states chose rate-based compliance). As discussed later, MWh energy savings can be translated in avoided CO_2 and avoidance of other pollutant emissions.

Examples of certificate or credit buyers could include EGUs under the CPP, utilities subject to energy-efficiency portfolio standards (EEPS) or energy efficiency resource standard (EERS), private purchasers in a voluntary trading market, and purchasers who need the credit in a "compliance" (cap-and-trade) market. They may want to own units denominated in either ERCs (or simply MWh) or tons of avoided CO_2 emissions, depending on the program or market in which they operate. Under the CPP, for example, an EGU may want to purchase ERCs to add to its tons/MWh denominator (in a rate-based state) or tons of CO_2 to cover its emitted mass limit (in a mass-based state). A university or industrial firm may want to purchase "carbon-offset" tons to meet voluntarily-adopted goals, whereas a utility may want to purchase MWhs to help meet its EERS/EEPS or other target.

A regional or national registry could provide a mechanism for all certificates, renewable-energy or energy-efficiency, to be qualified, validated, inventoried, issued, tracked, and retired. States could decide which registry/ies to use or recognize, such as, hypothetically, NEER.

Registry Outputs

The issuance and tracking of ERCs has been discussed in the preceding pages. With the registry's unique identifiers and retirement, these could be used for CPP compliance or sold into private or utility markets. Other emissions avoided by ESPC savings might also be tracked and traded via the registry (sulfur dioxide (SO_2), NOx, particulate matter, methane, mercury), depending on the evolution of markets that could cover the cost of quantification.

Early Action CPP Credits

A special CPP provision with potential relevance to EPSCs is EPA's "double credit" for early action CO_2 emission reductions achieved early (during 2020 and 2021, the two years preceding the start of the CPP's 2022-2024 compliance period) in low-income communities. This provision, known as the Clean Energy Incentive Program (CEIP) would give rate-based participating states' 2 credits per 1 MWh of avoided generation (in each of two years, 2020-2021) for qualifying demand-side energy efficiency projects and photovoltaic generation implemented in low-income communities. Mass-based plan states would receive a commensurate number of early action allowances. The proposed CEIP implementation rules (August 2016) state that eligible energy efficiency projects must commence operations on or after September 6, 2018. A Registry would be an important instrument for verifying, tracking, and submitting energy savings from ESPC projects for CEIP credit.

III. MODELS FOR COMPUTING EMISSIONS REDUCTIONS

Again, as stated above, the conversion of energy savings to avoided CO_2 emissions is not required to comply with the CPP; such a conversion may be valuable for other purposes, however, so it is retained in this paper. This section explains how such a conversion could be made utilizing the best available tools for that purpose.

Because the final CPP rule would award one ERC for each avoided MWh of consumption, there is an implied fixed national equivalence between MWh saved and tons of emissions avoided. In practice, however, the amount of CO_2 per MWh saved varies by place and time depending on the emissions rate of EGUs that operate on the margin and their emissions rates. Some states may want to have the capability of predicting a more detailed emission impacts for National Ambient Air Quality Standards (NAAQS), or other air quality management purposes. This paper discusses tools that can approximate that conversion regionally. A comprehensive national registry could have the capability of determining how a MWh should be converted to tons of CO_2 depending on where (and when – time of day) that MWh is saved.

An important resource for understanding electricity emission reductions calculations is EPA's "Roadmap for Incorporating Energy Efficiency/Renewable Energy Policies and Programs into State and Tribal Implementation Plans, Appendix I: Methods for Quantifying Energy Efficiency and Renewable Energy Emission Reductions."

In that report, EPA cites "The Emissions & Generation Resource Integrated Database" (eGRID) as a comprehensive source of data on the environmental characteristics of almost all electric power generated anywhere in the United States, including air emissions for nitrogen oxides, sulfur dioxide, carbon dioxide, methane, and nitrous oxide and emissions rates. EPA indicates that eGRID can be used to generate greenhouse gas registries and inventories, carbon footprints, emission inventories and standards, and avoided emission estimates.

The simplest emissions reduction computing approach, which would have satisfied the original CPP rule, would have been to use ESCO ESPC project annual M&V reports as the measure of MWh savings, and the eGRID non-baseload average historical tons of CO_2 per MWh in a given region as the measure of emission reductions.[16] (Historic regional non-baseload emissions data are readily available in eGRID).)[17]

[16] For instance, in Virginia, the DEQ computes this estimate annually, for in-state generation (e.g., 1,243 lb/MWh using 2006 data). Virginia, however, sits in two NERC sub-regions (mostly SERC but ECAR for the Western area), both including many "control areas" and characterized by large daily imports and exports of power. The power grid in Virginia therefore carries contributions from many out-of-state generators, in a mix depending on economically driven dispatching by PJM.

[17] https://www.epa.gov/energy/egrid

To increase credibility, these can be programmed into a parametric model, which allows the users to make their own model-prompted, critical input assumptions to test sensitivities to changing variables, especially if evaluating the effect of multiple project ECMs which may avoid the use of other emission producing fuels. [18]

The most complex approach would be to match predicted hour-by-hour electric demand reductions from all energy-efficiency projects against recent hour-by-hour records of the emission attributes and mix of all EGUs supplying the grid, adjusting for any planned changes of EGUs or their dispatching. This would require knowing what specific demand-reducing measures would be in effect over diurnal and seasonal variations, e.g. residential lighting efficiencies would be in effect mostly at night, commercial lighting during business hours, air conditioning efficiencies mostly at summer peak hours, etc. One could then enter the sum of the measures' impacts into hourly "bins" and map the results to the hourly EGU attributes mix historically seen (or expected) on the grid. Models exist also for this approach, but they tend to be proprietary and somewhat unfriendly to new users.[19]

In response to this challenge a number of compromise solutions had been proposed by federal agencies, consultants, software developers, utilities and regional transmission organizations (RTOs). AVERT (Avoided Emissions and Generation Tool) has recently been adopted by EPA and therefore carries intrinsic credibility. It was published in 2013 by Synapse Energy Economics, Inc.[20] , and was first made available to the public in February 2014 after peer review and substantial beta testing. In Synapse's opinion it accommodates the complexities on both demand and supply sides of the modeling equation, allowing non-expert users to compute emissions displaced by relatively simple descriptions of energy efficiency and renewable energy programs. A reference to AVERT and some comments on its use are given in Section VI.

The following is from the Synapse website[21]:

"AVERT is an open-access tool built for the EPA by Synapse to estimate the hourly emissions and generation benefits of energy efficiency and renewable energy policies and programs. AVERT allows non-expert users to measure displaced emissions of CO_2, SO_2, and NO_X, and avoided generation mitigated by state or multi-state programs. Stakeholders and regulators can also use the tool to identify likely units and regions impacted by different efficiency or renewable energy programs. The tool tracks each fossil unit's generation, heat input, and emissions and is able to identify likely changes in regional emissions when units are retired, replaced, or retrofitted with pollution controls. AVERT uses public data reported to the EPA by power plants in the U.S."

EPA claims that AVERT "helps you evaluate county, state and regional level emissions displaced by EE/RE

[18] CESI prepared such a model for use by DMME in Virginia, for example.

[19] A dynamic model is needed to make the conversion from reduced electrical consumption into CO_2 emission reductions. On the supply side, it has to accommodate changing sources of electricity generation, imports from out-of-state sources, expected dispatch order among generators supplying load, and emissions per MWh generated for each EGU supplying the grid at the times of energy-efficiency reduction. On the demand side, the model has to generate a profile of demand reductions by hour over an expected typical year, to correlate with the supply-side emissions profile.

[20] As a matter of disclosure, Synapse is a neighbor and frequent collaborator of the authors.

[21] http://www.synapse-energy.com/tools/avoided-emissions-and-generation-tool-avert.

programs—*without* requiring you to have specialized resources or electricity system expertise.” [22] AVERT cannot determine individual project-based credits, but it can help states answer broader planning questions regarding the overall benefits of quantifying emission impacts, as discussed above.

To test emission-reduction predictions made by these two widely used models, the authors ran an assumed level of electrical savings through eGRID and AVERT. The results are summarized in the following paragraphs. There will always be differences in such predictions when using different models, as illustrated in this case. Two of the major causes of different results are (a) using "non-baseload" emissions data (to reflect the expected mix of power plants on line); and (b) using more recent data in both models, which would take into account power plant retirements and shifting fuel use. In all cases, the models try to predict not only which power plants will be feeding the local grid at different times, but also which electrical savings measures will be reducing load on the grid at different times, both in the future. These predictions will always be inexact, but some models have earned greater credibility than others.

The primary data sources used for eGRID include data reported by electric generators to EPA’s Clean Air Markets Division and to the U.S. Energy Information Administration (EIA). eGRID annual non-baseload average emissions rate data are available at https://www.epa.gov/sites/production/files/2015-10/documents/egrid2012_summarytables_0.pdf.
The eGRID output is indicative of “regional average non-baseload emissions” reductions. As an average, it does not represent the marginal (hour-by-hour) peak load emissions reduction rates for specific ECM types or groups.

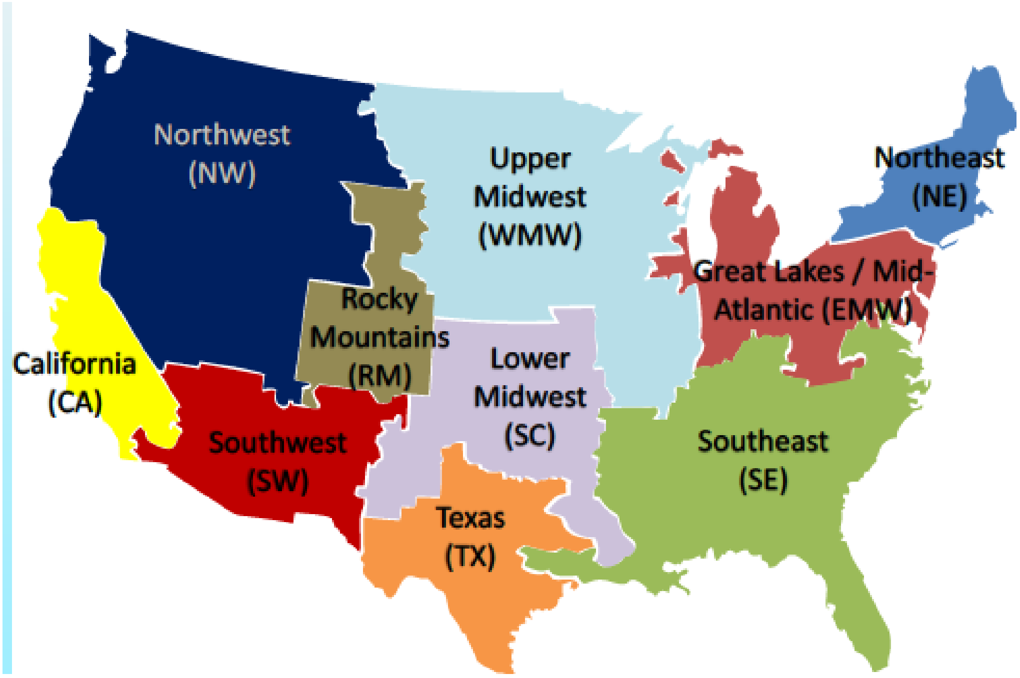
The eGRID regions are geographically grouped by the EPA as shown in this map:

[22] To download the free tool and to access more information about how to use it, including a user manual, one may visit epa.gov/avert.

Source:
http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2010V1_1_year07_SummaryTables.pdf>

The three states in the MEASURES grant are split up between four eGRID regions: Virginia is split between “SRVC” and “RFCW”; Kentucky is in “SRTV” and Georgia is in “SRSO.”

In contrast to the eGRID, the AVERT regional map below shows that all three MEASURES states are in the same Southeast Regional Database (95% of Virginia, and 91% of Kentucky and 100% of Georgia), which means one AVERT emissions reduction model run can simultaneously accommodate ECMs in aggregate across all three, in addition to yielding more accurate results than eGRID could provide. The magnitude of potential variance is illustrated in the below test evaluation comparison of the level of reductions estimated by both analytic approaches.



Several Input options are available to the user in AVERT to define the anticipated impact that EE will have on the existing generation mix in the geographic region designated by the user. The table below illustrates the types of impacts that are available.

Enter EE impacts based on the % reduction of regional fossil load		
Reduce generation by a percent in some or all hours		
Apply reduction to top X% hours:	0%	% of top hours
Reduction % in top X% of hours:	0.0%	% reduction
And/or enter EE impacts distributed evenly throughout the year		
Reduce generation by annual GWh:	161.3	GWh
OR		
Reduce each hour by constant MW:	0.0	MW
And/or enter annual capacity of RE resources		
Wind Capacity:	0	MW
Utility Solar PV Capacity:	0	MW
Rooftop Solar PV Capacity:	0	MW

The user can enter energy efficiency impacts as percent reductions to a percent of top hours, annually by GWh reduction, reduction of each hour by a constant MW, or, for renewable energy resources, annual MW capacity of Wind, Utility Solar PV, or Rooftop Solar PV.[23] Although AVERT was designed for program-level magnitude of energy reductions, it is the opinion of the authors of this report that these options would provide adequate adaptability to most typical comprehensive ESPC projects, especially if project data are aggregated across many ESPCs, as would be the case in a registry.

AVERT Test Process and Data Entry

AVERT is Excel-based with Visual Basic macros for Microsoft PC use. As the test progressed, Clean Energy Solutions, Inc., (CESI), MEASURES technical support partner, was able to edit the Visual Basic code such that AVERT macros would also execute on Apple/Mac products.

The seven megabyte AVERT module template is free for download on the Synapse website (http://synapse-energy.com/tools/avoided-emissions-and-generation-tool-avert). Once a regional database (the Southeast in this test) is selected for upload to the module, it expands to approximately 60 megabytes. When just one Impact Option is selected (annual GWh in the test) and the module computes the avoided emissions, it further expands to 300 megabytes. Multiple module runs will require significant hard drive capacity. In spite of the file size, the resulting output files are available for download and review, but the actual backup calculations are not retained and not reviewable by the user.

CESI conducted two tests of AVERT, using two sets of data and two input options, and compared results with predictions from running the "eGRID" simulation. (See Appendix A.) We found that the eGRID estimate will not always vary significantly from the AVERT estimate depending on the timing of the electricity savings relative to grid production mix. Occasionally, depending on the specific ECM mix, the eGRID annual non-baseload average may be more appropriate (although that will not often be the case). However, if AVERT is applied correctly it will yield a reasonably accurate assessment of emissions reductions. The same cannot be said of the eGRID method.

AVERT provides an output map showing the locations and intensity of regional displacements so one can see exactly where the marginal emissions reductions are occurring. AVERT allows user modification of the preset regional databases such that one could delete a generation asset if one knew it was off-line or coming off line in the near future. AVERT also allows for a future-year run simulation.

Our test results support AVERT as a model that would allow non-expert users to compute reasonably accurate marginal emission reductions quickly and at a reasonable cost. As the best available tool for this purpose, AVERT's output could be discounted by some factor to overcome the degree of error that its authors acknowledge. It is currently worthy of consideration as a tool for converting verified electricity savings into predicted CO_2 emission reductions for Virginia and its partner states.

IV. REGISTRY DESIGN

[23] See the "AVERT Overview and Training Manual" for a more detailed explanation of each impact option.

There are many supply-side electric-energy registries in the U.S., most launched since 2001. Some, such as NEPOOL GIS and PJM-GATS,[24] deal with both conventional generation attributes, like fuel source, technology, heat rate, emissions per MWh, location, and time of generation, as well as renewable-energy attributes, like source, time, location, and type of renewable generation. All allow tracking of each MWh generated from "source to sink," or EGU to the utility or other purchaser, including across state, region, and registry boundaries. This is possible because of EPA's publication of each EGU's generation-attributes data,[25] which is essential in predicting the emission impact of energy-efficiency programs. These registries attach to each MWh a tag or certificate describing its environmental attributes. In the case of renewable generation sources, these attributes are renewable energy certificates, and can be detached from actual energy and traded as separate commodities.[26]

On the demand side, a few of these registries also track energy-efficiency reductions in electric demand, attach energy efficiency certificates to each MWh of reduction, and identify its attributes, such as program source, time, and location.[27] In addition, many demand-side-only registries have sprung up in response to the possibility of widening markets. The American Carbon Registry, a nonprofit enterprise of Winrock International, has registered innovative credits in areas like forestry, wetlands restoration, landfill gas, cook stoves, and other environmental projects, but has also been approved as an offset project registry in the California cap-and-trade program. The Climate Action Reserve has also been approved by the California Air Resources Board as an official registry and issues carbon credits in other jurisdictions.[28] APX supplies the underlying software for these as well as many of the supply-side registries. VCS and Gold Standard operate the largest international registries and publish standards for validation and verification. A UN-sponsored protocol, The Clean Development Mechanism, approves registration of international projects.

In all cases, the central function of a demand-side registry is to issue certificates that are credible and meet the criteria of traceable uniqueness, verifiability with computational rigor, transparency, and additionality. In the Partner States, the extra criteria of local sourcing and long lifetimes are recommended

A registry is recommended to validate emission reduction designs, verify that the reductions have actually been achieved, and retire them so they cannot be double-counted. To sustain this activity in the

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[24] The New England Power Pool has sponsored for years a generation information system (GIS), with features similar to the generation attributes tracking system (GATS) supported by the PJM Interconnection.

[25] EPA collects emission data (six pollutants, now including CO_2) at 5-minute intervals. See epa.gov/eGRID for specific power-plant emissions; also see http://camddataandmaps.epa.gov/gdm/. Projections of likely future emissions are also available.

[26] The residual energy is often called "null power," and theoretically no one can then take credit for its attributes; however, its associated emission rate can still be computed and associated with its load by the utilities that buy it.

[27] The GIS in New England has done this for some time. The North American Renewable Registry, which serves states not included in the larger registries, and the NC Renewable Energy Tracking System also track energy savings and register energy efficiency and renewable energy certificates.

[28] The GIS in New England has done this for some time. The North American Renewable Registry, which serves states not included in the larger registries, and the NC Renewable Energy Tracking System also track energy savings and register energy efficiency and renewable energy certificates.

private economy, such reductions may be offered for sale in voluntary markets for “carbon offsets,” and potentially in the compliance market that could occur under the CPP. The proceeds of such sales can be used to expand further the energy-efficiency work in each participating state. Both energy-efficiency and renewable-energy emission reductions will be available for registration and sale, and renewable energy measures are becoming increasing common in ESPC.

For CPP compliance, State plans must demonstrate that emission standards and state measures (if applicable) are non-duplicative and that the tracking system used to administer a state’s rate-based emission trading system provides transparent, electronic, public access to information about program and project eligibility applications, including EM&V plans, and regulatory approval status. The Plan offers flexibility for EE providers to select from three broad categories of EM&V methods to determine savings. These categories include project-based M&V, deemed savings, and comparison group approaches such as randomized control trials (RCT). Regardless of the approach selected, the Plan proposes that annual savings values must be quantified and independently verified using these EM&V methods annually on a recurring basis over the effective useful life of the EE project or measure in order to ensure accurate and reliable savings values.

For the registry to achieve potential CPP and market-support objectives, it will need to:

1. Require applicants seeking ERCs, allowances or other compliance instruments to meet minimum requirements under the rule (Section II, VI).
2. Validate the programs that produce the savings, and verify the claimed savings against criteria important to the audiences.
3. Demonstrate consistency with CPP or other crediting requirements.
4. Issue certificates.
5. Track credits over time and assign a unique identifier to each unit so that they can be sold and retired (Section VI).
6. Provide sufficient income to support the operation.
7. Create reports for publishing to stakeholders and the public.

Some of these functions will be elaborated on more fully in the following section, “Critical Design Components.”

Other criteria that the registry will need to enforce are:

a) *Uniqueness:* Each certificate will represent one unit saved or avoided (MWh or therm saved, ton of CO_2 not emitted, etc.) and will be given a serial number so that its ownership and retirement can be tracked publicly, and no double counting will be possible.

b) *Independent verification:* Energy savings claimed for compliance purposes may need to be vetted by an independent verifier; this would be required, for instance, for issuance of ERCs under the CPP.

c) *Locality:* To satisfy compliance requirements and to promote marketing, the certificates issued by the registry must evidence energy efficiency and/or renewable energy activities that occurred in the participating state.

d) *Transparency:* Transparency to the public of documentation supporting the validity of projects, registered energy savings, and issuance, transfer, and retirement of certificates is necessary to assure the credibility and integrity of the registry process and the Registry's support of compliance and voluntary markets. Initially the Registry will register MWh. Translation to CO_2 and other emissions (e.g., NO_x, SO_2) would be additional steps predicated on registration of electricity savings. Other steps could include registering non-electricity energy savings and concomitant avoided emissions.[29] Transparency is necessary to assure credibility.

The aforementioned NEER project will provide a registry roadmap that will consider critical registry design criteria described above at least in regard to electricity savings, and possibly for wider application. As described on NEER's website[30]:

"The NEER would:

> Provide a consistent, robust framework for energy efficiency to be included as "eligible resources" in federal and state plans;
>
> Demonstrate the eligibility and verification of energy efficiency projects, particularly voluntary private sector efficiency actions, according to eligibility standards proposed by individual states, a group of states, or the U.S. Environmental Protection Agency; and,
>
> Facilitate the opportunity for inter- and intrastate trading.

The NEER minimizes the costs and administration associated with energy efficiency programs and policies, including public and private sector voluntary programs and policies, addresses concerns about potential double counting of energy savings, and creates greater transparency of energy efficiency programs and resulting benefits."

V. CRITICAL DESIGN CONSIDERATIONS FOR A REGISTRY

Measurement and Verification of Energy Savings

The International Performance Measurement and Verification Protocol (IPMVP) allows users to measure and verify reductions in energy consumption, and is almost universally used by ESCOs. One must distinguish, however, between electrical and thermal reductions, since only electrical energy reductions will affect EGU emissions. The units to be tracked, validated, registered, and verified by a registry could include units of avoided consumption of fossil fuels, and the means to that avoidance will need to be rigorously established to the satisfaction of all stakeholders: state air quality and energy agencies, regional and federal offices, host customers, contractors, financiers, and EPA. At the present time, it is not known if the NEER registry would be set up to track avoided consumption of all fossil fuels.

Data Collection

[29] In principle a registry could include non-energy emissions avoidance (e.g., methane, nitrous oxide, hydrofluorocarbons abatement) and other attributes (e.g., water quantity and quality impacts).
[30] https://www.theclimateregistry.org/thoughtleadership/energy-efficiency/.

It is essential to provide for the reliable collection of emission-reduction data. Eventually the registry will want to cast as wide a net as possible in registering reductions that can be sold into compliance and voluntary markets.[31] This means gathering ESPC results for state and local government clients as well as private market sectors. The "front end" of the registry will be a searchable database of EE and RE installations, which will be valuable in itself. DOE's "eProjectBuilder," (ePB)[32] can serve as a valuable tool for tracking, ensuring consistent reporting, and providing project transparency (e.g., M&V documentation links) for energy savings (and derived emissions avoidance) from ESPC projects (and possibly other building or facility energy efficiency projects) if the templates provided would actually be populated by ESCOs in every case. ePB provides authorized users with a standardized, secure online platform for collecting, housing and reporting their ESPC project data.

Consumption vs. Economic Savings

The "savings" reported by ESCOs to their customers are generally in dollar terms, and may include the results of peak demand reductions, thermal efficiencies, fuel-switching, avoided repair costs, maintenance savings, and more. However, it is necessary to have energy unit savings (MWh, Btu, therms) data that separates electricity from onsite fuel consumption and other pertinent energy inputs (e.g., purchased steam or chilled water from district energy systems) to derive avoided CO_2 or other emissions. ESCOs should report and their customers require energy unit savings.

Conversion of Reduced Consumption into Emission Reductions

As mentioned above, the current rate-based CPP rule would have established a simple, national equivalence ratio of one MWh avoided to one ERC and would not require an actual conversion to CO_2 avoided by state or region. Such a conversion, however, is important to establish confidence in trading markets beyond CPP requirements. As discussed previously, the EPA provides tools such as eGRID and AVERT to allow good estimates of avoided emissions due to electricity savings. Well-known emissions factors (such as EPA's "AP-42: Compilation of Air Emission Factors")[33] can be used to derive avoided emissions from reduced onsite fuel use.

Tracking

The registry, on behalf of each claimant, must set up an account for annually independently verified credits and potentially manage the account over time until all its certificates are retired.

VI. CONCLUSION & NEXT STEPS

A registry, such as the proposed NEER, can provide a means to enhance the cost-effectiveness, transparency, and credibility of energy efficiency projects and programs to help meet both regulated

[31] The impact of ratepayer-supported programs may have an important place in the state CPP implementation plans, but emission-reduction credits from those programs may belong to the utilities and/or host facilities and not be easily captured for sale by the Registry.

[32] ePB is a free system developed and managed on behalf of the Department of Energy's Federal Energy Management Program (FEMP) and Office of Weatherization and Intergovernmental Programs (WIP) by Lawrence Berkeley National Laboratory (LBNL).

[33] https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emission-factors.

and voluntary energy savings and air quality objectives. It can support better recognition and potential monetization of energy savings credits derived from ESPC and other projects and programs, particularly non-utility-ratepayer-funded efforts. This could provide additional value to energy efficiency project providers and their customers. Further, the verification and tracking of energy savings afforded through a registry can strengthen the robustness of energy and air quality planning performed by state energy offices and environmental regulators; i.e., they can have better confidence in the efficacy of energy efficiency projects and programs.

Proper operation of an energy efficiency registry is dependent on, among other things, good quality M&V to validate energy savings and tracking of such savings. Those topics, focused on ESPCs, have been central to the MEASURES project, as has the translation of energy savings into avoided pollutant emissions. These have been the focus of this paper and other MEASURES project work covering varied state ESPC practices, recommended principles for ESPC M&V, pilot application of eProjectBuilder and recommendations for its enhancement, and an emissions calculation roadmap.[34]

As the MEASURES project concludes, and as the NEER project proceeds, one next step that is underway is the sharing of MEASURES products and insights with the NEER project team. MEASURES project partner states will consider opportunities for enhancing the reporting and tracking of ESPC-derived energy savings to better recognize ESPC program efficacy and identify areas for improvement. This can be done in collaboration with local governments and other public bodies that use ESPCs as well as with the ESCO community, including with the National Association of Energy Service Companies (NAESCO) and the Energy Services Coalition and its state chapters. States can consider the potential for a registry to support broader state policy objectives, including for energy efficiency, energy reliability and security, and air quality.

Among other steps will be for State Energy Offices to strengthen their exchanges with air quality regulators, public utility commissions, and other pertinent agencies to enhance collaboration and more effectively achieve their goals. The MEASURES partners states and organization will also continue to engage with each other, other states and stakeholders, and the ongoing NEER project to explore evolving registry development and to strengthen ESPC and other energy efficiency approaches to meet state objectives.

[34] The project produced several relevant white papers, including "Evaluation, Measurement and Verification Protocols" and "Recommended ESPC M&V Principles Development." These and other project papers are available at: http://seealliance.org/initiatives/state-local-utility-policy/emv-approaches-performance-contracting/.

Appendices

A. AVERT Test Runs

<u>Test #1</u> - CESI selected "Reduce generation by annual GWh" for simplicity and as a reasonable comparison to the eGRID annual average non-baseload data for Virginia. Using DMME's Virginia Energy Management Program (VEMP) EPC electricity reductions for ESCO-reported projects completed in 2013, we entered 161 GWh annually and assumed that all electricity reductions were coincident with every hour of marginal non-baseload generation for the entire year. We then uploaded AVERT's Southeast database for 2013.

AVERT Regional Displacement Results

Southeast, 2013 AVERT

Output: Annual Regional Displacements

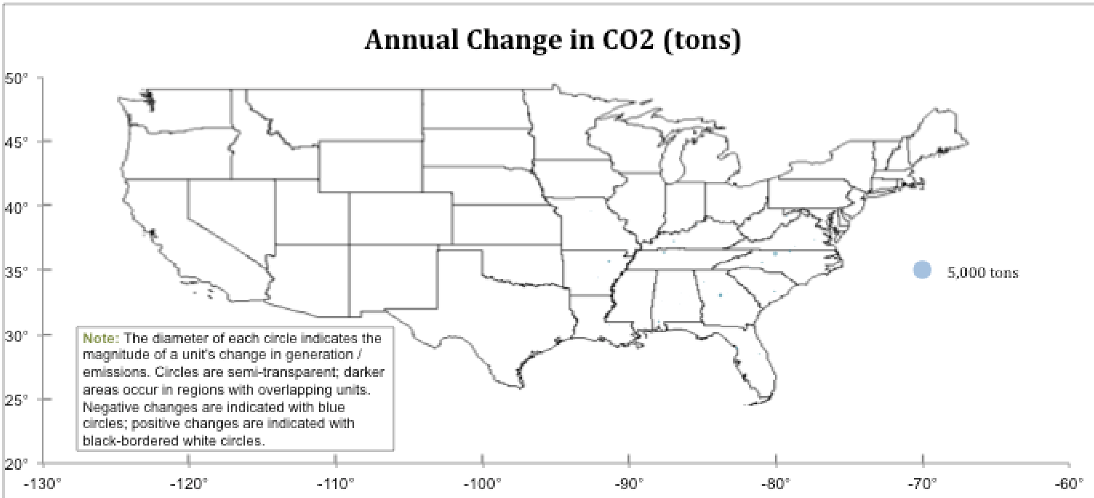
Click here to return to Step 4: Display Outputs

	Original	Post-EERE	Impacts
Generation (MWh)	774,484,400	774,323,600	-160,800
Total Emissions			
SO_2 (lbs)	1,757,262,300	1,756,926,500	-335,700
NO_x (lbs)	882,301,100	882,135,700	-165,400
CO_2 (tons)	594,878,600	594,769,400	-109,100
Emission Rates			
SO_2 (lbs/MWh)	2.269	2.269	
NO_x (lbs/MWh)	1.139	1.139	
CO_2 (tons/MWh)	0.768	0.768	

Negative numbers indicate displaced generation and emissions.
All results are rounded to the nearest hundred. A dash ("—") indicates a result greater than zero, but lower than the level of reportable significance.

AVERT calculated a regional CO_2 displacement of 109,100 tons.

AVERT also provides an output map showing the locations and intensity of regional displacements so one can see exactly where the marginal emissions reductions are occurring. The test map shows the following dispersion, with much of the reduction in states in the region (especially North Carolina) other than the three MEASURES states (33% in MEASURES states and the remainder in other states in the region):



Appendix B is AVERT's output of, "Annual Displacement Data by County," which lists the Southeast region emissions reductions breakdown state-by-state, county-by-county.

Comparison of AVERT to eGRID

In this test, AVERT's CO_2 displacement result is about five times greater than the 19,000+ ton eGRID-based estimate derived by applying the eGRID annual non-baseload CO_2 value for the eGRID region Virginia is in (using the eGRID 2010 values which is the last year available). The 2013 electric system (as modeled in AVERT) and the 2010 data from eGRID likely differ to some extent though probably not enough to account for the difference.

The AVERT Users Manual contains the following instruction for entering the annual GWh impact value:

"You may have an estimate of the total amount of energy that is targeted or required to be reduced by a program in a given year, but lack information about the distribution of those reductions over the course of the year. "Reduce generation by annual GWh" simply distributes those savings evenly over all hours of the year. The user inputs a total number of GWh expected to be saved in a single year. This may be a highly erroneous assumption if savings are targeted from residential or commercial customers, for whom energy efficiency measures tend to target peak use reductions. However, an industrial or refrigeration efficiency program may be well represented by a constant reduction across most hours of the year. Use this option with close attention to the types of programs assumed in your analysis."

The DMME ESPC database currently does not include enough detail regarding the actual ECM mix in EPC projects to allow us to enter the appropriate impact values in the various categories available in AVERT. The anticipated use of eProjectBuilder (ePB), or some other tracking system, may allow the AVERT user to enter more detailed data in the correct impact categories, thereby yielding a more accurate assessment of reductions at the margin.

The eGRID estimate will not always vary significantly from the AVERT estimate. Perhaps our decision to select annual GWh reduction is not appropriate for all of the electricity savings from the VEMP program in 2013. Perhaps the eGRID annual non-baseload average is more appropriate (although that will not often be the case). However, if AVERT is applied correctly it will generally yield a more accurate assessment of emissions reductions than would eGRID.

Test #2: In this test, CESI analyzed six years of anonymous ESPC project- and ECM-level cost, square foot and electricity savings data provided to CESI by NAESCO and LBNL. Three markets were included in the data set: K-12 schools, local government buildings and college/university facilities. Three ECM categories were represented: sixteen projects involved only lighting improvements; 343 major HVAC improvements; and 116 minor HVAC improvements. From the data we calculated several national average values: an investment of $5.25/sq.ft. (in 2012 dollars) and 2.86 kWh saved per sq.ft. These values were also calculated for each of the three ECM sub-categories.

We then performed a "what-if" exercise in which we assumed a first-year 3-state total EPC investment of $200 million. Applying the derived national factors to that level of investment yielded a total of 108,907 MWh saved. Of that, the proportion of "lighting" savings derived from NAESCO data is about 2% of the total MWh saved, or 3.4 GWh. Marginal representations of these kWh savings values were then entered in the AVERT model as follows:

Enter EE impacts based on the % reduction of regional fossil load		
Reduce generation by a percent in some or all hours		
Apply reduction to top X% hours:	1%	% of top hours
Reduction % in top X% of hours:	0.5%	% reduction
And/or enter EE impacts distributed evenly throughout the year		
Reduce generation by annual GWh:	3.4	GWh
OR		
Reduce each hour by constant MW:	0.0	MW
And/or enter annual capacity of RE resources		
Wind Capacity:	0	MW
Utility Solar PV Capacity:	0	MW
Rooftop Solar PV Capacity:	0	MW

The 3.4 GWh lighting savings is entered as an annual GWh reduction. One must then recognize that the remaining 105,400 MWh (mostly from major HVAC) is the upper limit of potential MWh savings both at the generation margin, since that is the total annual savings predicted by the ESCOs. We then backed into a reasonable marginal MWh reduction by iterating the "% of top hours" and "% reduction in the top hour," in several AVERT model runs. One satisficing result is 1% of top hours and .5% reduction in that top hour. The AVERT output looks like this:

	Original	Post-EERE	Impacts
Generation (MWh)	778,932,000	778,865,300	-66,700
Total Emissions			
SO_2 (lbs)	1,700,627,700	1,700,374,900	-252,800
NO_x (lbs)	820,429,100	820,328,700	-100,400
CO_2 (tons)	597,909,100	597,894,400	-14,600
Emission Rates			
SO_2 (lbs/MWh)	2.183	2.183	
NO_x (lbs/MWh)	1.053	1.053	
CO_2 (tons/MWh)	0.768	0.768	

This 66,700 MWh generation reduction (which includes the 3.4GWh) indicates that about 2/3rds of the total MWh savings occurred at the margin. The test illustrates that a $200 annual EPC investment may provide savings somewhat noticeable against the Southeast region total. Of course, the EPCs from following years would add to that reduction. It also illustrates that the upper limit of gross CO_2 emissions reductions for $200 million invested is about 22,000 tons (1.33 times the 14,600 tons calculated by AVERT in the Impact/CO_2 row above). This is based on the AVERT 2013 Southeast database, which introduces a degree of error as well.

Other studies and technical resource manuals like VEIC's "2010 Mid-Atlantic Technical Reference Manual"[35] may be used to increase accuracy of aggregated ECM MWh AVERT inputs for the Southeast region.

Another potentially valuable AVERT output is "Annual Displacement by County," which breaks down the calculated emissions reductions by county in each state in the region. It can be used by each state to define the CO_2 emissions reductions for this savings scenario that occur within the geographic boundaries of the state. See Appendix B for an example of emissions displacement by County.

AVERT does have some geographic and temporal limitations that need to be accounted for, as pointed out in email correspondence from a Kentucky MEASURES' team member. If one imagines a state that produced within its borders all power needed 24/7 from a single source and imported none, one could be confident of the CO_2 emission reductions from its EE. However, as soon as the local dispatching starts to admit more than a single source, one has to consider both how those sources are brought on line at the margins and how EE measures themselves affect load over time. The AVERT model makes some more realistic--but imperfect--assumptions. One could make better models (e.g., looking at local dispatching at the margins and individual ECM profiles), and some modelers have done that, but they become increasingly difficult to use. AVERT updates regional mixes annually, but one still would have to discount the impact of early years' calculations. Also, the impact of installed ECMs will likely change over time.

AVERT does allow for user modification of the preset regional databases such that one could delete a generation asset if one knew it was off-line or coming off line in the near future. AVERT also allows for a future-year run simulation.

[35] "Northeast Energy Efficiency Partnerships, 2014, "Mid-Atlantic Technical Reference Manual, Version 4.0," http://www.neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V4_FINAL.pdf.

B. "Annual Displacement Data by County" (AVERT output)

Output: Annual Displacement Data by County

State	County	Peak Gross Generation, Post-EERE (MW)	Annual Gross Generation, Post-EERE (MWh)	Annual Displaced Generation (MWh)	Annual Displaced SO2 (lbs)	Annual Displaced NOx (lbs)	Annual Displaced CO2 (tons)	Annual Displaced Heat Input (MMBtu)	Ozone Season Displaced SO2 (lbs)	Ozone Season Displaced NOx (lbs)
GA	Bartow	3,179	17,098,600	1,600	1,800	1,000	1,600	1,600	1,600	700
GA	Chatham	141	653,000	-400	-4,600	-1,600	-300	-300	-3,100	-1,100
GA	Cobb	2,390	17,225,400	2,900	ñ	ñ	1,000	1,000	ñ	ñ
GA	Coweta	688	825,400	-2,100	-43,400	-7,000	-2,100	-2,100	-30,800	-5,000
GA	Dougherty	62	87,300	ñ	-1,500	-500	-100	-100	-700	-200
GA	Effingham	1,965	8,840,200	-1,000	-4,700	-3,200	-300	-300	-3,500	-1,900
GA	Floyd	441	1,013,400	-900	-1,300	-1,500	-1,000	-1,000	-1,200	-1,000
GA	Glynn	29	7,300	-100	-500	-500	ñ	ñ	-100	ñ
GA	Hart	98	34,400	-300	ñ	-200	-200	-200	ñ	-100
GA	Heard	3,545	15,936,700	2,500	700	100	2,100	2,100	500	-200
GA	Houston	217	219,200	200	ñ	ñ	100	100	ñ	ñ
GA	Jackson	635	347,100	-1,400	-100	-500	100	100	ñ	200
GA	Mitchell	112	96,400	200	ñ	200	100	100	ñ	200
GA	Monroe	3,520	20,717,900	1,000	100	1,100	1,200	1,200	-700	600
GA	Murray	1,094	2,012,900	1,500	ñ	100	700	700	ñ	100
GA	Polk	212	156,300	600	ñ	300	400	400	ñ	200
GA	Putnam	1,113	2,758,500	-2,200	-66,800	-10,700	-2,200	-2,200	-55,000	-7,900
GA	Talbot	295	233,700	300	ñ	100	200	200	ñ	100
GA	Upson	431	532,600	800	ñ	300	700	700	ñ	300
GA	Walton	441	253,800	-1,100	ñ	-600	-200	-200	ñ	-300
GA	Washington	161	74,900	-200	ñ	-100	-100	-100	ñ	-100
KY	Carroll	2,066	13,858,700	-200	ñ	-400	-100	-100	-200	-400
KY	Clark	686	517,600	-2,300	ñ	-300	-400	-400	ñ	ñ
KY	Daviess	413	2,644,400	100	900	ñ	100	100	900	100
KY	Hancock	260	1,178,300	-700	-1,100	-2,600	-800	-800	-800	-1,900
KY	Henderson	316	2,544,500	-100	-100	ñ	-100	-100	-100	ñ
KY	Jefferson	2,181	12,656,100	-400	-2,000	-1,700	-400	-400	-1,500	-1,400
KY	Marshall	257	166,800	-800	ñ	ñ	-200	-200	ñ	ñ
KY	Mason	1,442	9,519,800	-500	-300	-200	-400	-400	-200	-200
KY	McCracken	1,151	7,677,700	-300	3,500	500	500	500	4,200	1,500
KY	Mercer	1,199	3,521,800	-1,900	-1,700	-2,500	-1,400	-1,400	-1,900	-1,700
KY	Muhlenberg	2,221	15,769,700	2,000	-1,000	3,500	2,000	2,000	-400	3,000
KY	Ohio	409	3,204,900	-300	-1,200	-200	-300	-300	-900	-100
KY	Pulaski	320	1,119,500	-700	-5,600	-1,200	-600	-600	-4,500	-900
KY	Trimble	1,879	8,910,000	-2,000	-500	-800	-1,400	-1,400	-300	-600
KY	Webster	520	4,029,500	-100	-3,800	-400	-100	-100	-3,000	-300
VA	Buckingham	565	3,238,200	900	ñ	ñ	400	400	ñ	ñ
VA	Caroline	800	773,100	-600	-100	-400	500	500	ñ	400
VA	hesapeake (Cit	745	1,555,900	-1,700	-13,000	-2,700	-1,100	-1,100	-9,100	-1,600
VA	Chesterfield	1,709	9,673,700	100	100	-400	300	300	100	-400
VA	Fauquier	949	866,400	-700	-100	100	800	800	ñ	500
VA	Fluvanna	636	2,920,400	100	ñ	700	100	100	ñ	400
VA	Halifax	917	6,081,000	-100	-100	-400	-100	-100	-100	-300
VA	Hanover	715	3,634,600	-1,200	ñ	100	ñ	ñ	ñ	200
VA	Henrico	237	50,600	-900	-500	-2,100	-700	-700	ñ	-1,100
VA	Hopewell (City	228	812,400	100	-100	1,000	300	300	ñ	900
VA	King George	253	933,200	-200	-100	-100	ñ	ñ	-100	-100
VA	Louisa	631	848,400	-1,600	-100	-500	-100	-100	ñ	100
VA	Prince William	1,015	3,788,400	-1,500	-11,000	-3,100	-1,300	-1,300	-7,800	-2,200
VA	ichmond (City	197	255,200	-200	-200	-100	-200	-200	ñ	ñ
VA	Surry	284	54,800	-1,000	-600	-1,700	-500	-500	ñ	-600
VA	Warren	65	209,200	ñ	ñ	ñ	ñ	ñ	ñ	ñ
VA	York	960	1,162,100	-3,300	-34,900	-9,500	-2,700	-2,700	-25,600	-7,000

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